

Claims

1. A method of detecting a frequency of an optical signal, such method comprising the steps of:

providing an optical carrier frequency locked to an axial mode of a first optical resonator of known free spectral range;

providing a reference optical resonator having a known free spectral range that differs from that of the first optical resonator;

locking an optical reference signal to an axial mode of a reference optical resonator producing an optical reference signal that is spectrally offset from said optical carrier frequency by a spectral quantity within a predetermined bandwidth from that of the optical carrier frequency;

mixing the optical carrier frequency with the optical reference signal frequency thus generating a difference signal as a beat frequency; and

measuring a frequency of a difference signal.

2. The method of detecting a frequency of an optical signal as in claim 1, further comprising locking an optical reference frequency to an axial mode of the reference optical resonator closest to that of the carrier frequency producing an optical reference signal that is spectrally offset from said optical carrier frequency by a spectral quantity less than the known free spectral range.

3. The method of detecting a frequency of an optical signal as in claim 1, further comprising defining said optical

carrier signal as existing within a communications band having a plurality of optical carriers.

4. The method of detecting a frequency of an optical signal as in claim 3, further comprising measuring an optical frequency of each of the plurality of optical carriers in order to separate each spectrally adjacent optical carrier by a predetermined frequency whereas each optical carrier signal is locked an assigned axial mode of an optical resonator of known free spectral range.

5. The method of establishing a plurality of optical carriers as in claim 4 further comprising locking the plurality of optical carrier signals to a common optical resonator.

6. The method of establishing a plurality of optical carriers as in claim 4 further comprising locking the plurality of optical carrier signals to a plurality of optical resonators.

7. The method of establishing a plurality of optical carriers as in claim 6 further comprising locking the plurality of optical resonators to a common free spectral range.

8. The method of establishing a plurality of optical carriers as in claim 5 further comprising a method whereby each optical carrier is locked to an assigned axial mode of a common optical resonator whereas each assigned mode may support a mutually exclusive frequency.

9. The method of establishing a plurality of optical carriers as in claim 7 further comprising a method whereby

each optical carrier is locked to an assigned axial mode of a particular resonator whereas each assigned mode may support a mutually exclusive frequency.

10. A method of detecting a frequency of an optical signal, such method comprising the steps of:

defining a carrier frequency grid whereby the frequency space between optical carriers on said grid is determined;

providing a means by which an optical carrier frequency is maintained on a carrier grid frequency;

defining a reference frequency grid whereby the frequency space between optical references on said reference grid is determined and different from that of the carrier frequency grid;

providing a means by which an optical reference signal is maintained on a reference grid frequency within a predetermined bandwidth from that of the optical carrier frequency;

mixing the optical carrier frequency with the optical reference signal frequency thus generating a difference signal as a beat frequency; and

measuring a frequency of a difference signal.

11. The method of detecting a frequency of an optical signal as in claim 10 wherein the reference optical carrier is maintained on a reference grid frequency nearest that of the first optical carrier frequency.

12. The method of detecting a frequency of an optical signal as in claim 10, further comprising defining the optical carrier frequency grid as corresponding to the harmonics of a known fundamental frequency.

13. The method of detecting a frequency of an optical signal as in claim 12, further comprising defining the optical reference frequency grid as corresponding to the harmonics of a known fundamental frequency different from that of the carrier frequency grid.

14. The method of detecting a frequency of an optical signal as in claim 13, further comprising defining a fundamental difference signal as the difference between the respective fundamental frequencies of the carrier and reference grids.

15. The method of detecting a frequency of an optical signal as in claim 14, further comprising a means by which an optical carrier signal is maintained on a frequency of the optical carrier frequency grid.

16. The method of detecting a frequency of an optical signal as in claim 15, further comprising a means by which an optical reference signal is maintained on a frequency of the optical reference frequency grid within a predetermined bandwidth of the optical carrier signal frequency.

17. The method of detecting a frequency of an optical signal as in claim 16, further comprising defining the predetermined bandwidth to be less than the fundamental frequency of the carrier frequency grid.

18. The method of detecting a frequency of an optical signal as in claim 17, further comprising defining the optical carrier and reference frequencies as corresponding to the same harmonic number of their respective fundamental frequencies.

19. The method of detecting a frequency of an optical signal as in claim 16, further comprising establishing a difference

frequency between respective harmonics of the optical carrier and reference frequencies such that the frequency difference between adjacent sets of such respective harmonics may vary by an integer multiple of the fundamental difference frequency.

20. The method of detecting a frequency of an optical signal as in claim 19, further comprising mixing the optical carrier frequency and optical reference frequency to generate a unique difference frequency as a Vernier succession of difference frequencies is established whereby mixing of adjacent harmonics of the optical carrier and reference frequencies respectively shall vary by one fundamental difference frequency.

21. The method of detecting a frequency of an optical signal as in claim 10, further comprising defining said optical carrier signal as existing within a communications band having a plurality of optical carriers.

22. The method of establishing a plurality of optical carriers as in claim 21, further comprising defining the optical carrier frequency grid as corresponding to the harmonics of a known fundamental frequency.

23. The method of establishing a plurality of optical carriers as in claim 22, further comprising defining the optical reference frequency grid as corresponding to the harmonics of a known fundamental frequency different from that of the carrier frequency grid.

24. The method of establishing a plurality of optical carriers as in claim 23, further comprising defining a fundamental difference signal as the difference between the

respective fundamental frequencies of the carrier and reference grids.

25. The method of establishing a plurality of optical carriers as in claim 24, further comprising generating a plurality of harmonics of the fundamental frequency of the carrier frequency grid.

26. The method of establishing a plurality of optical carriers as in claim 25, further comprising a means by which an optical reference signal may be tuned to a frequency of the optical reference frequency grid within a predetermined bandwidth of an optical carrier signal frequency.

27. The method of establishing a plurality of optical carriers as in claim 26, further comprising defining the predetermined bandwidth to be less than the fundamental frequency of the carrier frequency grid.

28. The method of establishing a plurality of optical carriers as in claim 27, further comprising defining the optical carrier and reference frequencies as corresponding to the same harmonic number of their respective fundamental frequencies.

29. The method of establishing a plurality of optical carriers as in claim 26, further comprising establishing a difference frequency between respective harmonics of the optical carrier and reference frequencies such that the frequency difference between adjacent sets of such respective harmonics may vary by an integer multiple of the fundamental difference frequency.

30. The method of establishing a plurality of optical carriers as in claim 29, further comprising mixing an optical carrier frequency and optical reference frequency to generate a unique difference frequency as a Vernier succession of difference frequencies is established whereby mixing of adjacent harmonics of the optical carrier and reference frequencies respectively shall vary by one fundamental difference frequency.

31. The method of detecting a frequency of an optical signal as in claim 1 wherein the step of locking an optical frequency to an axial mode of an optical resonator further comprises phase modulating the optical frequency at a frequency corresponding to a known free spectral range.

32. The method of detecting a frequency of an optical signal as in claim 31, further comprising resonating the phase modulation sidebands within an optical resonator.

33. The method of detecting a frequency of an optical signal as in claim 32, further comprising phase modulation of the optical carrier frequency at a second frequency that is not resonant within the resonator of known free spectral range.

34. The method of detecting a frequency of an optical signal as in claim 33, further comprising detecting the phase of the resonant phase modulation sideband signal.

35. The method of detecting a frequency of an optical signal as in claim 34, further comprising detecting the heterodyne beat at the difference frequency between the resonant and non-resonant phase modulation sideband components.

36. The method of detecting a frequency of an optical signal as in claim 35 further comprising detecting the phase of the heterodyne beat frequency by mixing said beat frequency with the difference frequency between the resonant and non-resonant phase modulated sideband components in orthogonal phase within a mixer.

37. The method of detecting a frequency of an optical signal as in claim 36, further comprising feedback of the mixer output corresponding to the detected phase of the heterodyne beat frequency to control a resonant frequency of the optical resonator.

38. The method of detecting a frequency of an optical signal as in claim 37, further comprising defining said optical carrier signal as existing within a communications band having a plurality of optical carriers.

39. An apparatus for detecting a frequency of an optical signal within a communications band having a plurality of optical carriers separated by a predetermined fundamental frequency, such apparatus comprising:

providing a reference optical signal spectrally offset from an optical carrier of the plurality of optical carriers by a spectral quantity within a predetermined bandwidth;

mixing the reference optical signal with the plurality of optical carriers;

detecting the difference frequency between the reference optical signal and a closest optical carrier frequency as a heterodyne beat frequency; and

measuring a frequency of a heterodyne beat signal.

40. The apparatus for detecting a frequency of an optical signal as in claim 39, further comprising providing a reference optical signal spectrally offset from a closest optical carrier of the plurality of optical carriers by a spectral quantity less than the predetermined fundamental frequency;

41. The apparatus for detecting a frequency of an optical signal as in claim 39, further comprising generating the spectrally offset reference optical signal.

42. The apparatus for detecting a frequency of an optical signal as in claim 41 wherein generating the spectrally offset reference optical signal further comprises phase modulating the reference signal with the frequency corresponding to the free spectral range of a reference optical resonator that supports the plurality of spectrally offset reference optical signals.

43. The apparatus for detecting a frequency of an optical signal as in claim 42, further comprising means for resonating the carrier and phase modulation sidebands of the reference optical signal.

44. The apparatus for detecting a frequency of an optical signal as in claim 43, further comprising means for detecting the resonated phase modulation sidebands of the reference optical signal.

45. The apparatus for detecting a frequency of an optical signal as in claim 44, further comprising phase modulation of the optical carrier frequency at a second frequency that is

not resonant within the resonator of known free spectral range.

46. The apparatus for detecting a frequency of an optical signal as in claim 45, further comprising detecting the phase of the resonant phase modulation sideband signal.

47. The apparatus for detecting a frequency of an optical signal as in claim 46, further comprising detecting the heterodyne beat at the difference frequency between the resonant and non-resonant phase modulation sideband components.

48. The apparatus for detecting a frequency of an optical signal as in claim 47, further comprising detecting the phase of the heterodyne beat frequency by mixing said beat frequency with the difference frequency between the resonant and non-resonant phase modulated sideband components in orthogonal phase within a mixer.

49. The apparatus for detecting a frequency of an optical signal as in claim 48, further comprising feedback of the mixer output corresponding to the detected phase of the heterodyne beat frequency to control a resonant frequency of the optical resonator.

50. The apparatus for detecting a frequency of an optical signal as in claim 49, further comprising controlling a resonant frequency of the resonator using the detected mixed phase modulated reference frequency and resonant phase modulation sideband frequency.

51. The apparatus for detecting a frequency of an optical signal as in claim 50, further comprising generating the plurality of optical carrier signal frequencies.

52. An apparatus for detecting a frequency of an optical signal within a communications channel having a plurality of optical carriers separated by a predetermined frequency spacing, such apparatus comprising:

a stabilized laser adapted to provide a reference optical signal spectrally offset from an optical carrier of the plurality of optical carriers by a spectral quantity within a predetermined bandwidth;

a photodetector adapted to mix the reference optical signal with the plurality of optical carrier frequencies to create a heterodyne beat frequency with a closest optical carrier frequency; and

an analyzer adapted to measure a frequency of a heterodyne beat signal.

53. The apparatus for detecting a frequency of an optical signal as in claim 52, further comprising the predetermined bandwidth that is less than the fundamental frequency of the optical resonator.

54. The apparatus for detecting a frequency of an optical signal as in claim 53, further comprising optical carrier and reference frequencies corresponding to the same harmonic number of their respective fundamental frequencies.

55. The apparatus for detecting a frequency of an optical signal as in claim 52, further comprising a resonator adapted to generate the harmonics of the free spectral range as a series of spectrally offset reference optical frequencies.

56. The apparatus for detecting a frequency of an optical signal as in claim 55, further comprising a phase modulator adapted to phase modulate the reference signal with the free spectral range frequency.

57. The apparatus for detecting a frequency of an optical signal as in claim 56, further comprising a detector adapted to detect the phase of the resonant phase modulation sideband of the reference optical signal.

58. The apparatus for detecting a frequency of an optical signal as in claim 57, further comprising feedback of the detected phase of the resonant phase modulation sideband to control a resonant frequency of an optical resonator.

59. The apparatus for detecting a frequency of an optical signal as in claim 58, further comprising a piezo-electric crystal disposed on an end of the resonator adapted to control a resonant frequency of the resonator using the detected phase of the resonant phase modulation sideband.

60. The apparatus for detecting a frequency of an optical signal as in claim 58, further comprising an electro-optic crystal contained within the resonator adapted to control a resonant frequency of the resonator using the detected phase of the resonant phase modulation sideband.

61. The apparatus for detecting a frequency of an optical signal as in claim 58, further comprising a thermally sensitive material contained within the resonator adapted to control a resonant frequency of the resonator using the detected phase of the resonant phase modulation sideband.